RECOMMENDED STANDARDS FOR INSTALLATION AND MAINTENANCE OF HAULAGE ROADS

BY D. S. KINGERY AND T. F. CURRY

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D. S. Kingery[1] and T. F. Curry[2]

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INTRODUCTION

Efficient transportation is necessary to complement modern mechanized mining methods. The increasing trend toward high-capacity face loading equipment has demanded equally efficient haulage methods; this has been met by increasing mine-car sizes, using larger locomotives, and increasing haulage speeds, all requiring properly installed and maintained haulage roads specifically designed for this type of traffic. The recommendations and specifications included in this circular were made to point out salient factors important to the proper construction and maintenance of track haulage roads and to serve as recommended standards for track installation and maintenance.

GLOSSARY OF TERMS USED

Haulageway. - The track, walkway, trolley wire, feeder lines, signal and telephone lines, signals, telephones, support, and drainage of the entry referred to.

Subgrade. - The base upon which the ballast is laid.

Roadbed. - The ties and ballast upon which the rail is laid.

Surfacing. - Leveling, tamping, and final ballasting of track.

Turnout. - Two switch points with requisite switch plates and braces, head and back rods, two closure rails, frog, and parallel-ground switch throw. The turnout number is the number of the frog used in the turnout.

Switch. - Two switch points with requisite switch plates, and head and back rods.

Closure rails (Also known as filler rails or transfer rails). - The rails connecting the heels of the switch points with the frog.

New rail-inspection standard. - Rail must be absolutely free of horizontal or vertical bends, the ball or side of the rail must not be worn down more than 1/8 inch, and the top of the rail must be within 1/16 inch of level.

Point of switch. - Recommended 5 inches for all sizes to and including 60-pound rail, with 6-inch spread for 70- to 80-pound rail.

Splice bars. - Angle-type bars for splicing rail joints, differentiated from strap bars or fish plates.

Standard spiking. - Driving one spike on each side of the rail in each tie with spikes in staggered position, and outside spikes on the same edge of the tie.

Double spiking. - Driving two spikes on each side of the rail in each tie.

A.W.P.A. - American Wood Preserving Association.

SUMMARY OF HAULAGE-ROAD REQUIREMENTS

Haulage roads to permit high-speed, trouble-free transportation schedules require the following fundamental features:

Good roadbed.
Efficient drainage.
Tracks alined properly.
Economical grades.
Proper radius of curvature on turnouts.
Ties of proper size, well ballasted.
Good-quality track materials of proper size.
Good workmanship.
Regular and systematic maintenance.

CLASSIFICATION OF HAULAGEWAYS

Haulageways should be classified according to the service they are expected to perform in the transportation system. The following are general classifications, based upon the importance of the service expected and the type of construction materials used. All track construction should fall into one of the following classes.

Class A Track

Use. - Main-line haulageways in large-tonnage mines having long life and for all other high-speed or haulage operations with large mine cars.

Location. - The location and installation should be from a predetermined centerline established by engineers.

Grade. - The most economical grade should be established consistent with the expected life of the haulage road and the tonnage to be hauled.

Materials. - Sixty-pound rail or larger that will stand new rail inspection.

All ties should be treated to A. W. P. A. standards.

Splice bars with bolts and lock washers should be used, except where joints are welded.

Track bolts should be checked and retightened after 1 month's operation and occasionally thereafter.

Ballast. - Slag, crushed limestone, or other suitable material.

Gage rods and tie plates should be used where needed.

Class B Track

Use. - (1) Main-line haulage in small mines.

(2) Secondary haulageways in large mines.

Location. - The location and installation should be from a predetermined centerline established by engineers.

Grade. - The most economical grade should be established consistent with the expected life of the haulage road and the tonnage to be hauled.

Materials. - 40- to 60-pound rail meeting new-rail inspection standards.

Ties. - Treated or untreated depending upon proposed length of service.

Splice bars with bolts and lock washers should be used, except where joints are welded.

Track bolts should be checked and retightened after 1 month's operation.

Ballast. - Slag, crushed limestone or equivalent.

Gage rods and tie plates should be considered optional.

Class C Track

Use. - Intermediate, cross or panel haulageways, including room turnouts where locomotives, mechanical equipment, and large mine cars are used.

Location. - Predetermined centerline established by engineers.

Grade. - Most practical grade, based upon equipment and expected size of trips.

Material. - 40- to 60-pound rail, meeting new rail standards.

Splice bars with track bolts.

Ballast. - Mine refuse

Class D Track

Use. - Slow-speed gathering or service haulage.

Location. - No predetermined centerline.

Grade. - Minimum grading, based upon local conditions.

Material. - 30- to 40-pound rail.

Steel ties or untreated wood ties.

Track bolts with strap bars, angle type optional.

Ballast. - None, except where needed to hold track.

Special steel ties for portable turnouts.

Class E Track

Use. - Animal haulage or light motors with small cars.

Location. - No predetermined centerline.

Grade. - Minimum grading necessary.

Material. - 15- to 30-pound rail.

Untreated wood or steel ties.

Ballast. - Mine rock where the haulageway is used for main or secondary haulage purposes. No ballast in room entries.

Strap bars and track bolts.

These classes of haulageways described are for varying needs and should be considered construction options to be decided by the chief engineer, mine superintendent or other responsible person.

RECOMMENDATIONS FOR INSTALLATION

Location and Alinement

The location established for class A and B haulage roads plays an important part in the efficiency of the completed haulageway. The established centerline should be based upon obtaining a haulage road with the minimum curves consistent with the type of service expected over it. Past practice in many instances when new haulageways are constructed has been to conform the track to the entry, regardless of unnecessary curves that may be required. By first surveying the entry and plotting it to scale, a centerline requiring the minimum number of curves can be established. This procedure may require slabbing the rib at points, but the improved alinement will more than pay for this added expense. Frequent turns necessitate slower speed of trips with a consequent decrease in production.

Grade

The most economical grade consistent with the expected life of the haulage road and degree of traffic should be established. This can be accomplished by surveying the entry and plotting a profile of the grade variations. From this profile the most practical grade can be determined, as well as estimates of cost and the quantity of cut or fill work necessary. Where an abrupt change in grade occurs, vertical curves to permit a smooth change should be made. Although the initial expenditure for grading a mainline haulage road may seem high, the ultimate results justify this outlay. Uniformity of grade is highly desirable, even when heavy cuts or fills are necessary. The advantages of uniform grades are greater speed of traffic, larger trips per tractive effort, simplified drainage, and reduced bumping and jerking of cars with an accompanying reduction in spillage. Additional advantages are decreased track maintenance and probably reduced wrecks or derailments.

Clearance

Continuous clearance of at least 30 inches should be provided to permit travel on one side of the track from the mine portal to all working faces. This clearance should be measured from haulage-road obstructions to the farthest projections of moving equipment. A minimum of 12 inches should be maintained on the other or "tight" side. Where mechanical equipment is used that requires the operator to work or travel on the tight side, clearance on this side should also be not less than 30 inches.

Drainage

It is impossible to maintain tracks in good condition where the roadbed is saturated with water. Drainage of the haulage road is therefore of the utmost importance and must be provided before any new track is constructed. Wherever practicable, main drainage ditches should be in parallel headings rather than along the haulageway. Where drainage ditches are located in the haulageways, the roadbed of the track should be maintained above the level of the water, and the ditches should be protected to prevent their becoming obstructed (fig. 1, C). Where a drainage ditch crosses the haulage road, water should be conducted under the track through a tile or concrete trough.

Roadbed

Preparation of the roadbed is important to the efficiency of the operative haulage system. After the centerline and gradient have been established, the construction crew should prepare the subgrade (bottom of crossties) by leveling to the proper elevation either by filling (ballast) or cutting to grade level. Where headroom is essential, a minimum of ballast under the ties is desirable. The amount of ballast needed will vary under different conditions; however, 3 to 6 inches usually is sufficient. Ties can be laid directly on the mine floor, provided the floor is dry and the bottom material somewhat elastic. However, a more stable roadbed is obtained using ballast or fill under the ties for drainage, elasticity and load distribution.

Ballast

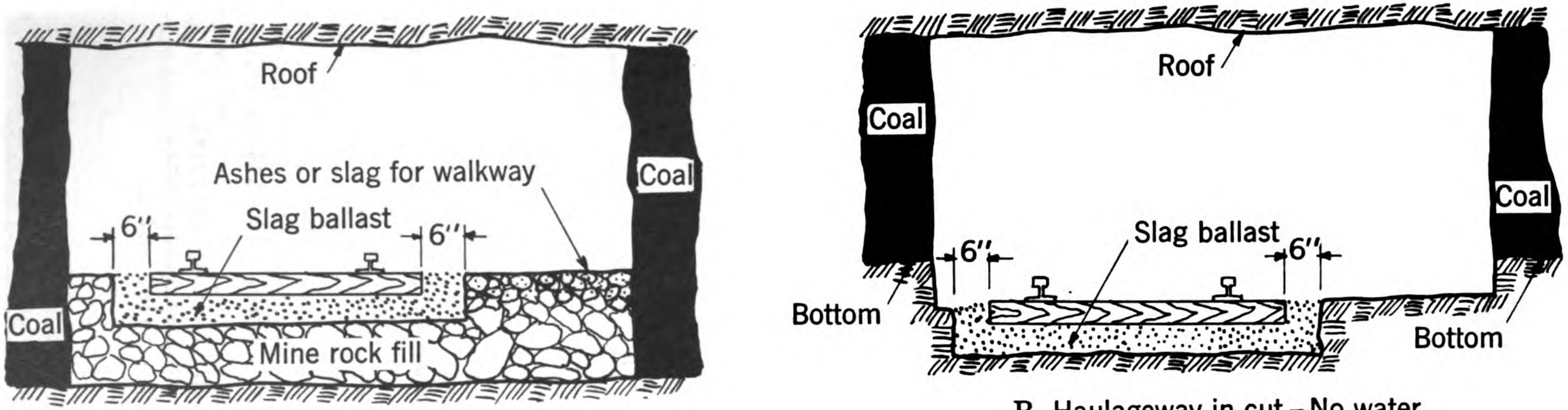
Ballast is the material filled in between and around ties. Ideal ballast must transfer the applied load over a large surface, hold the ties in place horizontally, permit the rail to be adjusted to grade line, carry off water, and produce an elastic roadbed. The materials most commonly used for ballast are crushed rock, slag, cinders, and mine refuse.

(1) Crushed limestone fulfills all the requirements of good ballast and disintegrates slowly; its chief disadvantage is cost.

(2) Crushed sandstone and slag are very good for ballast, except that both pulverize quite rapidly and will absorb water.

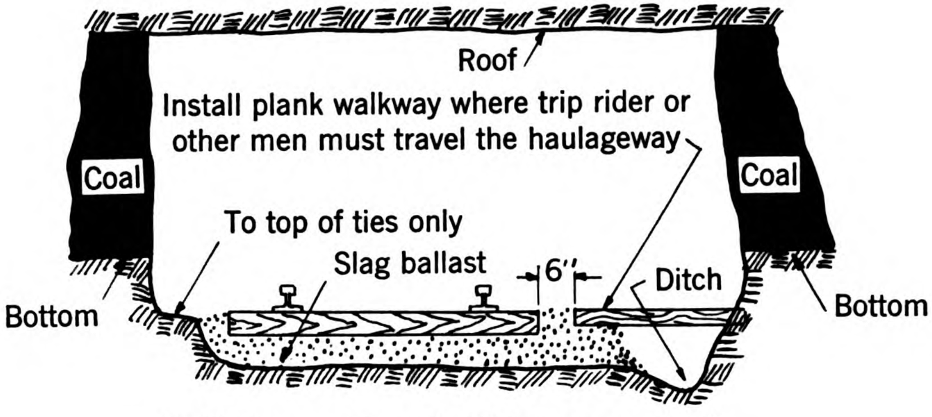
(3) Cinders and ashes make a cheap ballast; however, they absorb water, disintegrate quickly, and pack, thereby reducing track elasticity.

(4) Mine refuse is commonly used for track ballast. Such material is a poor ballast because it yields to the weight of the rolling stock, slacks and disintegrates with weathering, obstructs drainage, and is easily washed from the roadbed.



A Haulageway in fill

B Haulageway in cut – No water


Roof
Install plank walkway where trip rider or other men must travel the haulageway
Coal
Coal
To top of ties only
Slag ballast
6″
Ditch
Bottom
Bottom

C Haulageway in cut – Water encountered

Figure 1. - Recommended installation of haulage roads in cut or fill.

Rail Accessories

Selection of the proper size material for the haulage road is important and should be based upon the estimated life of the mine and the speed of traffic desired, as well as size of cars, size of proposed trips to be hauled, and maximum grades. The weight of rail used for main-line haulage varies from 60 to over 90 pounds per yard, with 60-pound rail most common; however, the present trend in new installations is toward 80-pound rail or heavier. Often heavy second-hand rail can be purchased at a lower cost per ton than lighter weight new rail, providing the advantage of a heavier track at a cost comparable to that of lighter rail. The size of the rail is important. A heavy rail, if properly installed, provides a trouble-free, smooth operating haulageway. However, unless a reasonable amount of maintenance work is done, very little advantage can be expected with heavy rails over lighter rail track.

When ordering track material, detailed specifications based upon the weight of rail, size of track bolts, track spikes, angle bars, and lock washers should be included. All material should be inspected by a competent person before any effort is made to put it into service.

TABLE 1. - Recommended size of track bolts[1]

Weight of rail (lb. per yd.)	Size of bolts (inches)	Weight of rail (lb. per yd.)	Size of bolts (inches)
20	1/2 x 2	50	3/4 x 3-1/4
25	5/8 x 2-1/4	55	3/4 x 3-1/2
30	5/8 x 2-1/2	60	3/4 x 3-1/2
35	5/8 x 2-3/4	65	3/4 x 3-3/4
40	5/8 x 3	70	3/4 x 3-3/4
45	3/4 x 3	80	7/8 x 3-3/4
		90	7/8 x 4-3/4

[1] Reference: Peele's Mining Engineers Handbook, 3d ed.

If the bolts used are too long, money is wasted, and the protruding bolts may be sheared off by derailments. Lock washers should be used on permanent installations, and track bolts should be kept tight to wedge the splice bars between the bottom and ball of the rail. Bolts should be inserted in alternate directions at the rail joints to prevent the possibility of all bolts being sheared in case of a derailment. The heads of track bolts should be lightly hammered when being tightened to assure tight joints, and all joint should be checked and loose bolts tightened at frequent intervals.

TABLE 2. - Recommended minimum sizes of standard mine ties and track spikes

Weight of rail (lb. per yd.)	Size of ties (inches)	Size of track spikes (inches)
25	3 x 5	2-1/2 x 1/2
40 - 50	4 x 5	3-1/2 x 1/2
60 - 75	5 x 6	4-1/2 x 1/2
60 - 80	5 x 7	4-1/2 x 1/2
85 - 100	6 x 8	5-1/2 x 9/16

Track spikes should penetrate the tie to within 1/2 to 3/4 inch of its thickness but never more than to within 1/4 inch from its underside. Spikes should not be driven directly opposite each other but should be staggered and driven vertically, with the last few blows hammered lightly to prevent bending or breaking the top of the spike.

The length of the tie varies with the track gage. The following are recommended minimum lengths for various gage widths.[2]

Track gage (inches)	Minimum length of tie
36 - 39	5 ft. 6 inches
40 - 44	6 ft. 0 inches
45 - 48	6 ft. 6 inches

Track gage and alinement are best maintained when tracks are kept in good surface. For track gages of 30 to 48 inches, the length approximately 2 feet, 6 inches, over track gage permits adequate tamping under each rail. Tracks subject to rain, freezing, or thawing may require ties 3 feet over track gage to maintain surface economically. Where light ties are used for main haulage tracks, they should be reinforced with welded cross rails or steel ties, in addition to the usual number of wood ties.

Rail Bonds

If the track is used as a power conductor, unless joints are welded, both rails should be bonded at each joint and cross-bonded at least every 200 feet. Special provisions should be made for bonding switches, frogs, or track openings to assure a continuous circuit. A common practice has been to bond only one rail. This practice constitutes false economy, since the severing of one bond disrupts the continuity of the circuit, creating potential hazards.

A continuous path for the current is necessary at all times from a viewpoint of safety, as well as maximum efficiency. Corroded splices, loose bonds, and broken rails are points of high resistance and are very likely to heat abnormally when current is flowing. Overheating at these points can cause ignition of combustible material in contact with them. Furthermore, increased resistance increases the voltage drop in the circuit, and low operating voltage induces heating in motor windings and trailing cables.

All bonds should be 4 - 0 size conductors or the equivalent.

Mine Ties

Ties are necessary to support the rails and distribute the weight of traffic throughout the roadbed. Consequently the size, spacing, and selection of mine ties plays an important part in the completed haulage road. The following recommendations are from specifications published by the American Mining Congress.

Quality. - All mine ties should be free from defects that could impair their strength or durability, such as decay, large splits, large shakes, numerous holes or knots, or a pronounced grain with a slant greater than 1 in 15. They should be straight, well hewed, sawed or cut square at ends, and have bottom and top parallel with the bark completely removed.

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[2] American Mining Congress, Standards for the Construction and Maintenance of Haulage Roads.

Dimensions. - Throughout both sections, between 6 and 18 inches from both ends. All mine ties should measure not less than 1/4 inch from dimensions specified. Ties that are much longer, shorter, wider, or 1/2 inch thicker than specified should be rejected.

Knots. - A large knot is one whose average diameter exceeds one-third the width of the surface on which it appears but may be allowed if occurring outside the critical section measured 6 to 18 inches from each end. Numerous knots or any number equaling a large knot should cause the tie to be rejected.

Split. - Splits in ties less than 5 inches long are permissible, provided satisfactory antisplitting devices have been applied.

Wood. - The following woods are recommended as suitable material for mine ties: Oak, locust, walnut, chestnut, mulberry, sassafras, beech, birch, maple, sycamore, hickory, elm, ash, and gum. Some of these woods are available locally in all mining areas.

Untreated Ties. - The average wood timber available for mine ties is not resistant to decay. Decay conditions vary, limiting the useful life of untreated mine ties to 2 to 5 years.

Treated Ties. - Treated ties have been known to last for 20 or more years without evidence of decay. The average wood's timber is suitable for preservative treatment by several pressure processes; consequently, when the expected life of a haulage track is longer than the average life of untreated ties, it is economical to use treated ties. With labor costs a major item, the extra cost of treated ties will be more than saved by eliminating the first renewal, with the added dividend of well-laid track requiring minimum maintenance.

The standard specifications for preservative treatment by pressure processes adopted by the American Wood Preservers Association are as follows:

Net retention of preservatives after treatment shall be:

(A) Creosote.

A. W. P. A. Grade 1, not less than 6 lb. per cubic foot of ties. Empty-cell process.

A. W. P. A. 80-20 creosote coal-tar solution, not less than 6 lb.per cubic foot of ties. Empty-cell process.

(B) Zinc chloride.

A. W. P. A. specifications. Not less than 1/2 lb. dry salt per cubic foot of ties. Full-cell process.

(C) Chromated zinc chloride. - Specifications - not less than 3/4 lb. dry salt per cubic foot of ties. Full-cell process.

(D) Wolman salts. - Not less than 3/10 lb. of dry salt per cubic foot of ties. Full-cell process.

The treatment of ties gives complete protection only as long as the outer or treated crust remains unbroken and where evaporation of the treating oils is retarded.

When treated ties are stored for long periods, they should be stacked close together and covered with earth or other material to prevent evaporation of oils. Treated ties that have been used should have the spike holes plugged immediately after removal from the track if it is planned to reuse them.

Treated ties are not recommended for temporary haulage roads, because in such installations they soon become spike-worn and do not provide adequate holding facilities.

CONSTRUCTION PROCEDURE

(1) Provide drainage as previously recommended.

(2) Clean the entry of miscellaneous debris and loose material.

(3) Prepare cut-and-fills; complete grading to subgrade previously established by engineers.

(4) Ascertain if enough material, tools, and supplies are available.

(5) Schedule the delivery of track and accessories in quantities that will minimize multiple handling and hand-labor transport at the site.

(6) Schedule the actual construction work by breaking the job down into component parts.

Track and Roadbed

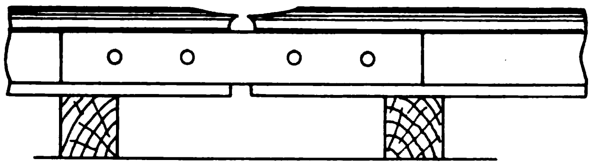
Straight Track. - Only a few rails should be laid at a time. These should be alined and surfaced before additional rail is laid. This will permit delivery of supplies over the semicompleted roadway.

Ties should be spaced according to the class of track or type of service expected. Ties should be close enough to support the moving load and prevent surface bending. Proper spacing and ballasting effect a uniform load, increase stabilization, and reduce maintenance requirements. The best ties should be used near rail joints but not placed directly under rail joints, since the hammering action of traffic concentrated on one tie ultimately causes the joint to become loose (fig. 2, B).

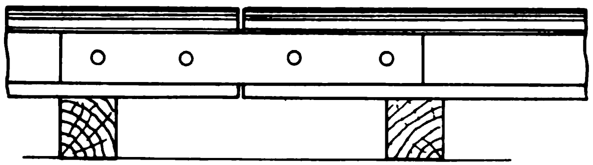
Long wooden ties, extending from rib to rib, should be placed at suitable intervals to assist maintaining the track alinement; long concrete ties spaced about every 100 feet serve the same purpose. The following table indicates suitable spacing distances between ties (fig. 3):

Recommended tie spacing, inches

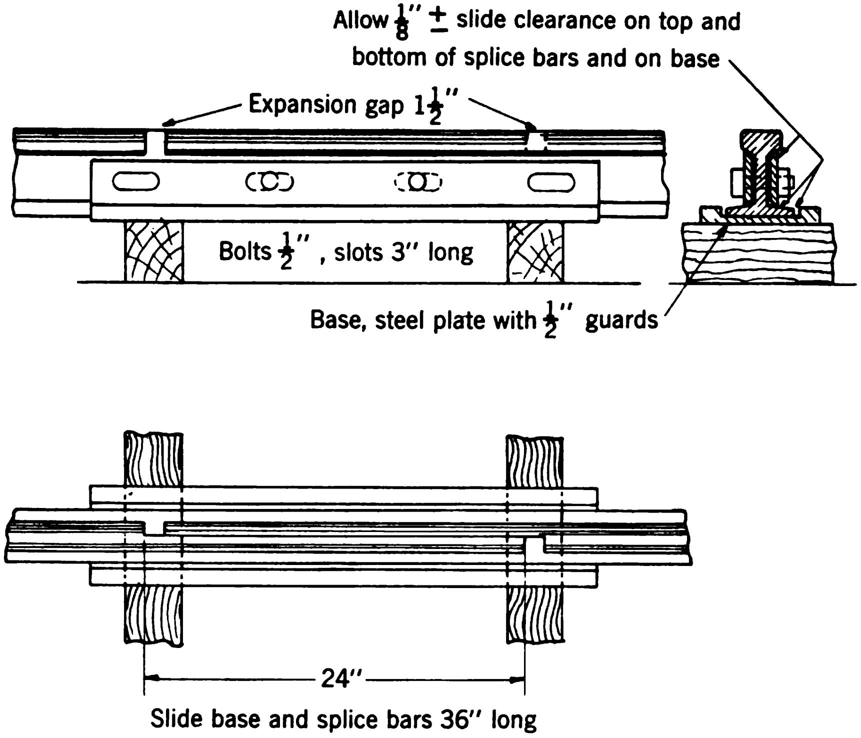
Class of track	Centerline to centerline	
	At joints	Intermediate
A	15	22
B	15	23
C	15	24
E	12	30



A Effect of wide rail joints



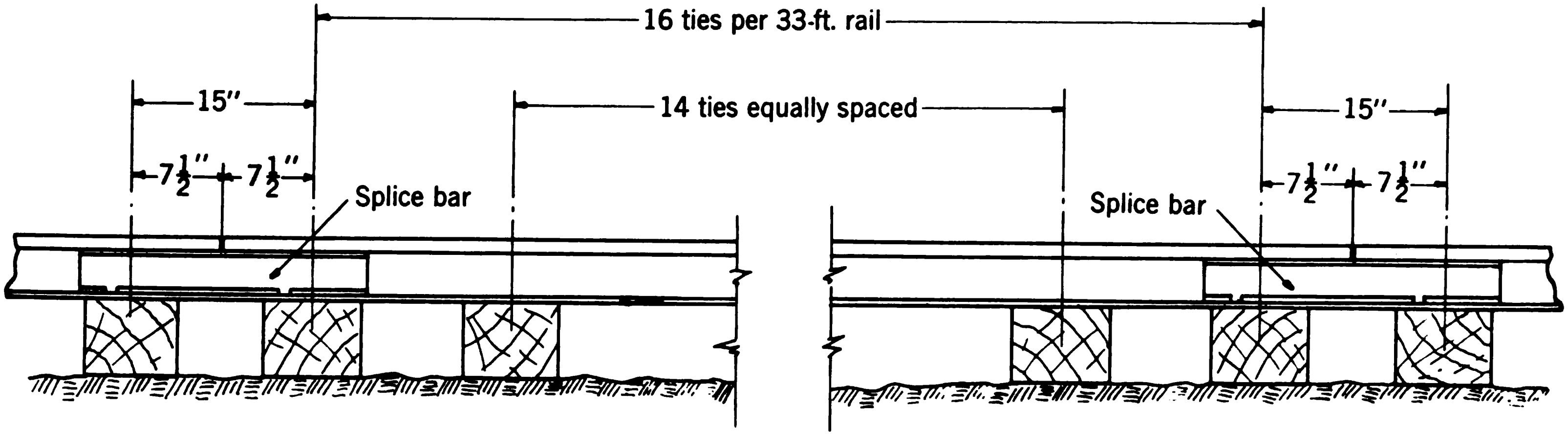
B Properly supported rail joint



Allow $\frac{1}{8}''$ ± slide clearance on top and bottom of splice bars and on base
Expansion gap $1\frac{1}{2}''$
Bolts $\frac{1}{2}''$, slots 3" long
Base, steel plate with $\frac{1}{2}''$ guards
24"
Slide base and splice bars 36" long

C Split-rail expansion joint

Figure 2. - Recommended rail-joint practice.



Note: On 90-lb. and 100-lb. rails, tie centers to be 24″

Figure 3. - Suggested tie spacing for one 60-pound rail.

When ties are placed care must be taken to assure adequate working space between them, because a small space may not permit room for adequate tamping.

Steel ties should be spaced close enough together to assure that the track remains rigid during normal traffic. In rooms with ordinary gathering service, 36-inch centers have proved satisfactory. In rooms with heavy equipment, 24-inch centers or less may be required.

Rail Joints. Rail joints should connect the rails so that they act as a continuous girder with uniform surfaces and alinement. Since expansion is usually unnecessary, underground rail joints should be butted together so that the upper surface of the rail joint is smooth. Where an opening exists between rail ends, a hammering action develops that causes the ends to flow and fill up the opening between joints causing a low place at the joint (fig. 2, A). The hammering effect continues at low joints, pounding ties, loosening track bolts, and causing low places in the roadbed. The practice of spacing rails to suit bolt holes is not recommended; the expense of redrilling holes to assure a tight joint will be far offset by reduced maintenance costs resulting from widely gaping rail joints (fig. 4).

Welded joints, by several processes, have been used in mine track for several years and in general have been satisfactory. Welded joints eliminate rail bonds, angle bars, and other joint fasteners and greatly reduce joint maintenance, since track without joints does not contain local points where maintenance problems are concentrated.

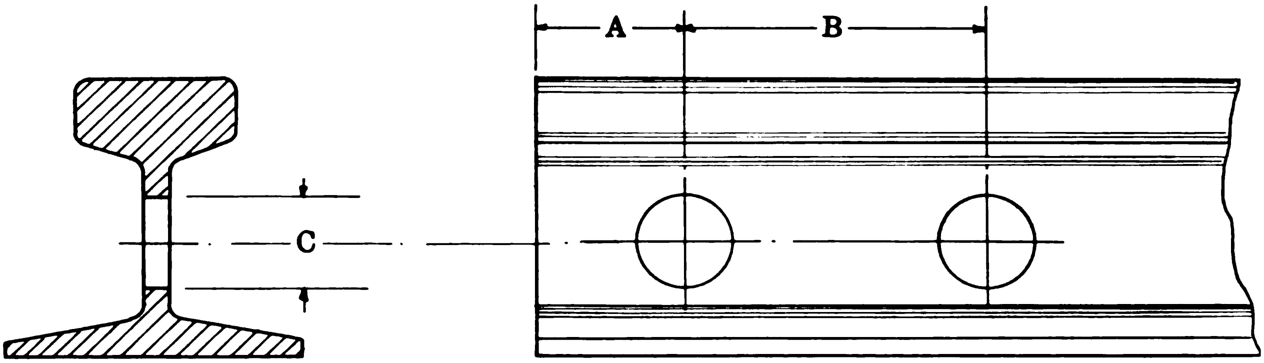
Rail joints should be staggered and tightly tamped rather than placed opposite each other. This provides a more stable haulage road. Compromise rail joints should be used when connecting rails of different weights. Where annual temperature variations require expansion joints outby the point of constant mine temperatures, a split-rail-type expansion joint (fig. 2, C) gives better service and does not have the disadvantages of rail gaps previously mentioned. When making the joint, the ends of the rails are cut down through the head, web, and flange to provide half-sections that fit along each other to form a new complete rail section. Half the bolt holes in each splice bar are slotted to permit bolts to slide as the rails expand or contract. The balance of the holes are not slotted to insure a rigid joint. Each rail has a fixed attachment to one splice bar and a sliding attachment to the other. The joint is set in a steel base to provide lateral stability and facilitate expansion.

Gage Rods. - There is a wide application for gage rods with wooden ties of poor holding quality or track that is subject to unusual lateral stresses, such as heavy and rapid traffic over curves.

The double-jaw type, capable of holding the rail against movement in either direction, helps to prevent rail tipping as well as spreading and is recommended over single-jaw types (fig. 5). The following sizes are recommended for various rail weights:

20 - 30 pound rail	7/8-inch diameter
40 - 60 pound rail	1-inch diameter
70 - 90 pound rail	1-1/4-inch diameter

Gage rods should not contain welds or splices, and lock washers should be used.



Weight of rail per yard	A	B	C	Diam. of bolts
20	2″	4″	5/8″	1/2″
30	2″	4″	3/4″	5/8″
40	2 1/2″	5″	3/4″	5/8″
50	2 1/2″	5″	7/8″	3/4″
60	2 3/4″	5 1/2″	7/8″	3/4″
70	2 3/4″	5 1/2″	7/8″	3/4″
80	2 3/4″	5 1/2″	1″	7/8″

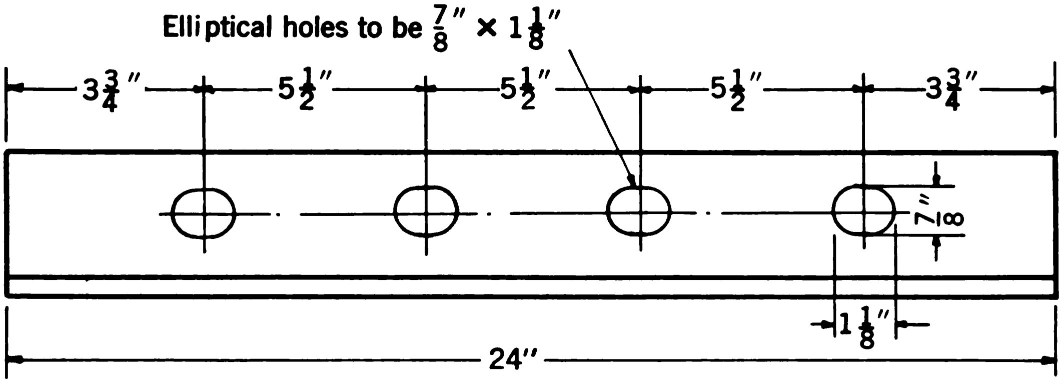
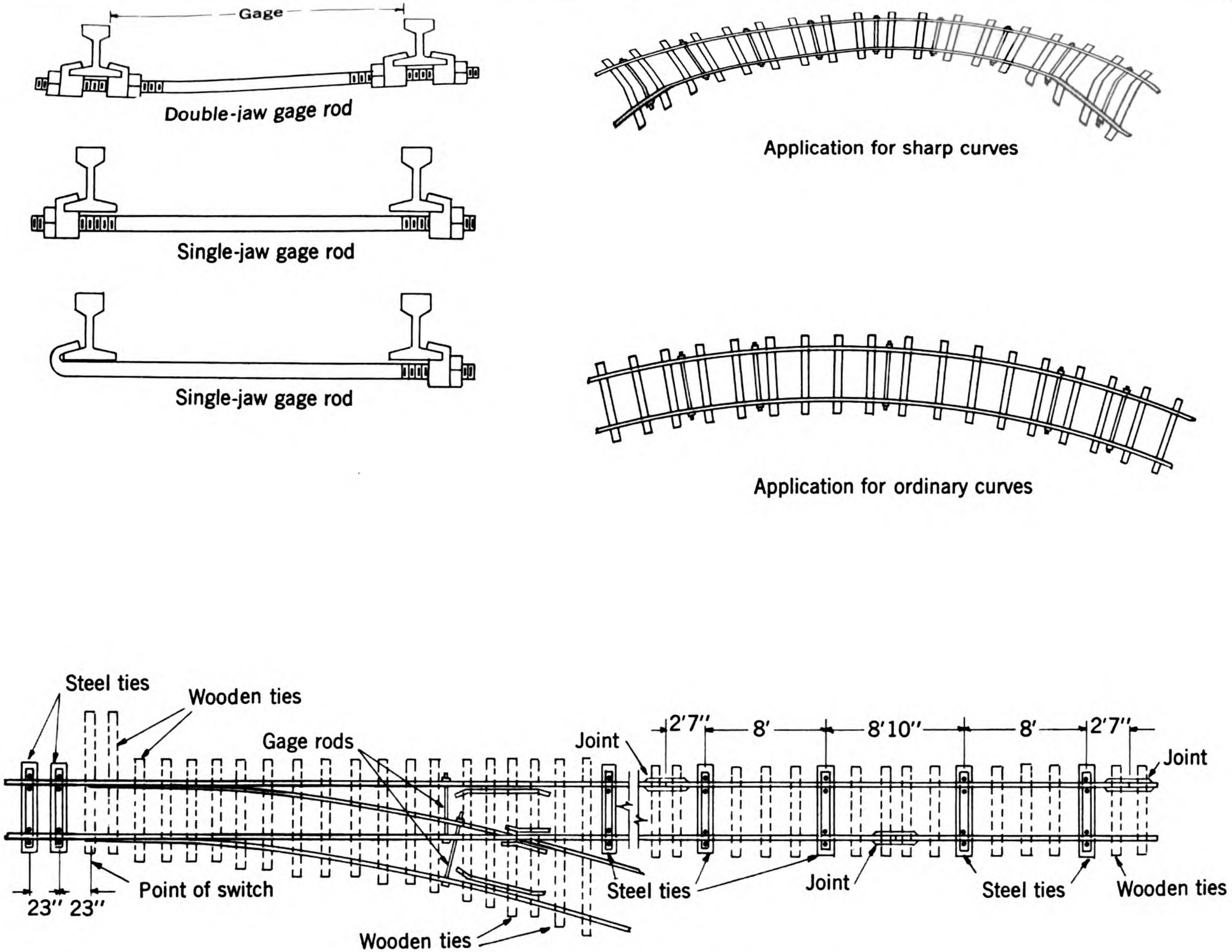


Figure 4. - Recommended practice for rail drilling.



Double-jaw gage rod

Single-jaw gage rod

Single-jaw gage rod

Application for sharp curves

Application for ordinary curves

Figure 5. - Example of gage rods and their use.

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Steel ties are often used for gaging mine track; under certain conditions they work satisfactory. However, it is necessary to constantly check and tighten the clip bolts, since after the clip bolts loosen the value of the tie as a stabilizer is greatly reduced.

Tie Plates. - Tie plates, except with switches (fig. 6), are not considered necessary with pressure-treated hardwood ties and when the standards of track construction and maintenance are adequate for operating conditions. With adverse conditions of drainage, inadequate roadbed, heavy traffic density, curves, and softwood ties, tie plates may be necessary. When tie plates are used, there should be four spikes to the tie. Spikes should be driven vertically, not slanted under the base of the rail or bent against it when driving. The last few blows should be light to prevent straining or breaking the head of the spike. Tie plates resist the lateral thrust of the rail and prevent side motion, which over a period of time causes excess rail wear and is detrimental to alinement.

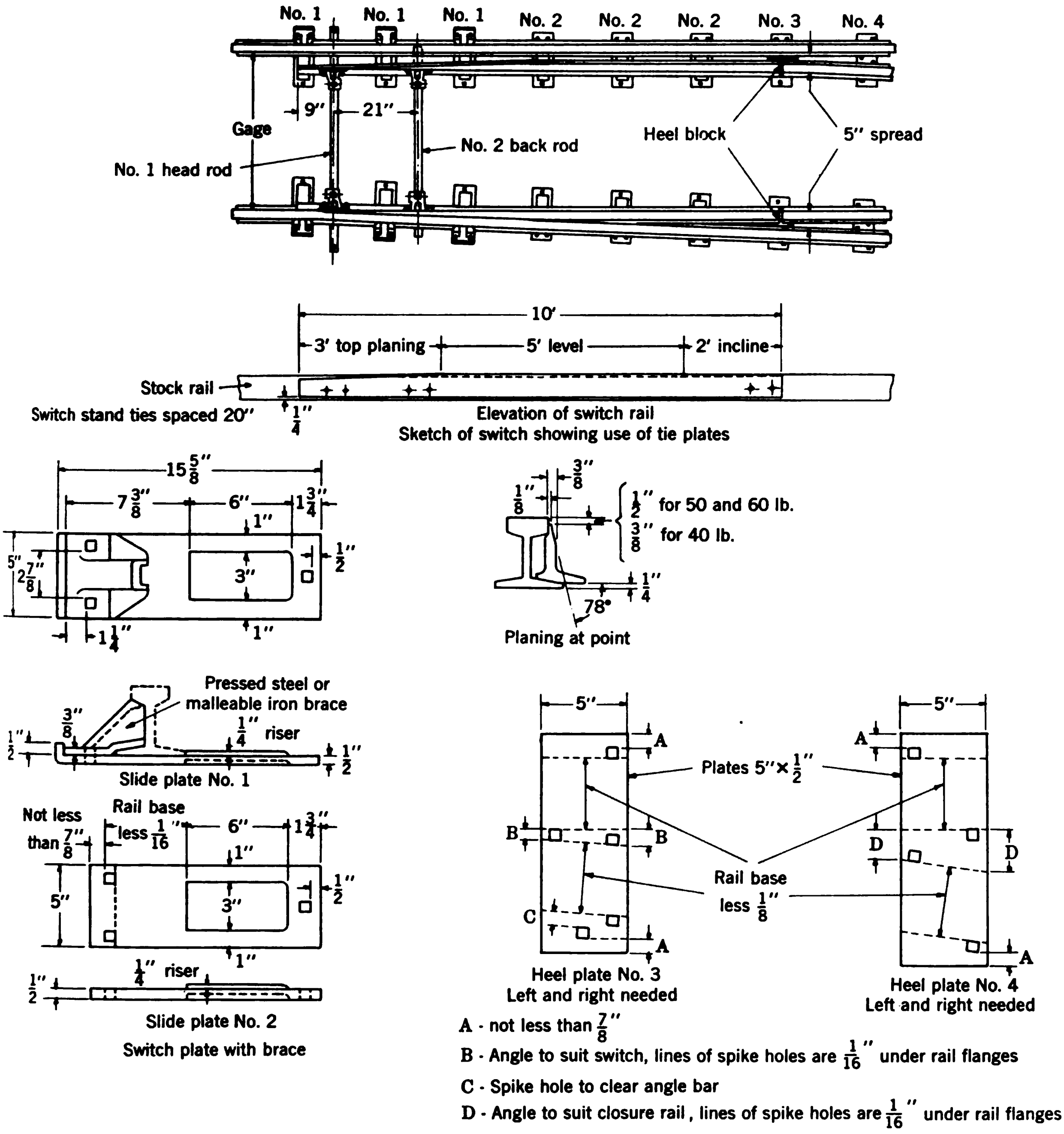
Superelevation on Curves. - The centrifugal force of a trip moving around a curve should be neutralized by raising the elevation of the outer rail above the elevation of the inner rail. The amount of super elevation (elevation above normal grade) depends upon the track gage, the radius at the curve, and the speed of the train. The practice of superelevating curves on class A and B haulage roads will reduce track-maintenance costs and should lessen the chances of serious wrecks or minor derailments. Table 3 shows outer rail elevations for different radii and haulage speeds. In actual practice, it is not considered necessary to superelevate less than 1/2 inch, and 5 inches of superelevation is considered the maximum practice for mine haulageways.

At the point of curvature where straight track passes to a circular curve, the track cannot be level and also permit the outer rail to be elevated. The most practical solution is to elevate the outer rail on the tangent starting 50 or more feet and gradually raising elevation until one half of the superelevation is reached at the point of curvature. The full superelevation should be reached approximately midway on the curve. To assist laying out or constructing haulage curves, middle-ordinate data (fig. 7) are desirable. Proper use of middle ordinate data, as given for 10-foot chords, will facilitate the work of the supervisor and workman during construction and permit an easy check of completed work with simple tools, such as a 10-foot string and a rule.

Installing Turnouts. - Turnouts (fig. 8) are commonly but incorrectly referred to as switches and are necessary to transfer rolling equipment from one track to another. The turnout is a very important part of the transportation system and unless properly installed and maintained is a constant source of trouble. A complete turnout consists of the following parts, which should be installed according to planned procedure.

1. Frog.
2. Switch (complete).
3. Straight and curved closure rails.
4. Guard rails.
5. Switch, stand complete with connecting rod.

The frog (fig. 9) establishes the number of the turnout, since the frog number determines the frog angle. The angle is the deciding factor pertaining to the use of the turnout.



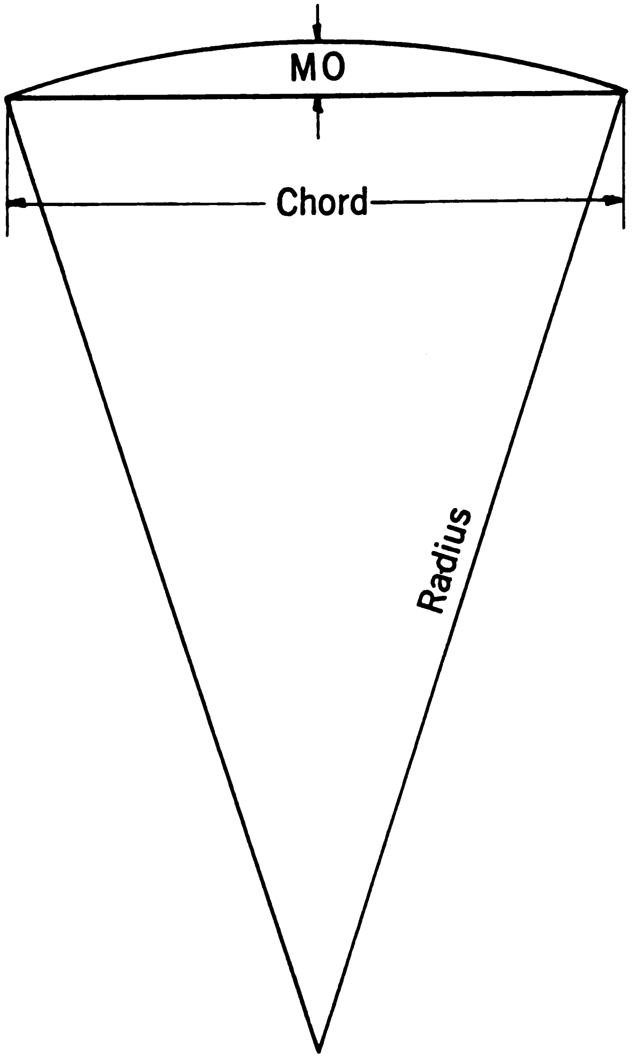
A - not less than 7/8"

B - Angle to suit switch, lines of spike holes are 1/16" under rail flanges

C - Spike hole to clear angle bar

D - Angle to suit closure rail, lines of spike holes are 1/16" under rail flanges

Figure 6. - Sketch showing types and use of tie plates for 40- to 60-pound rail switches.



Middle ordinates in inches for 10-foot chords			
Radius, feet	Centerline ordinate	Radius, feet	Centerline ordinate
10	$16\frac{3}{32}''$	50	$3\frac{1}{16}''$
12	$13\frac{1}{8}''$	60	$2\frac{1}{2}''$
15	$10\frac{9}{32}''$	75	$2\frac{1}{16}''$
20	$7\frac{5}{8}''$	100	$1\frac{1}{2}''$
25	$6\frac{1}{16}''$	125	$1\frac{1}{4}''$
30	$5\frac{1}{16}''$	150	1.0
40	$3\frac{7}{8}''$	200	$0\frac{3}{4}''$

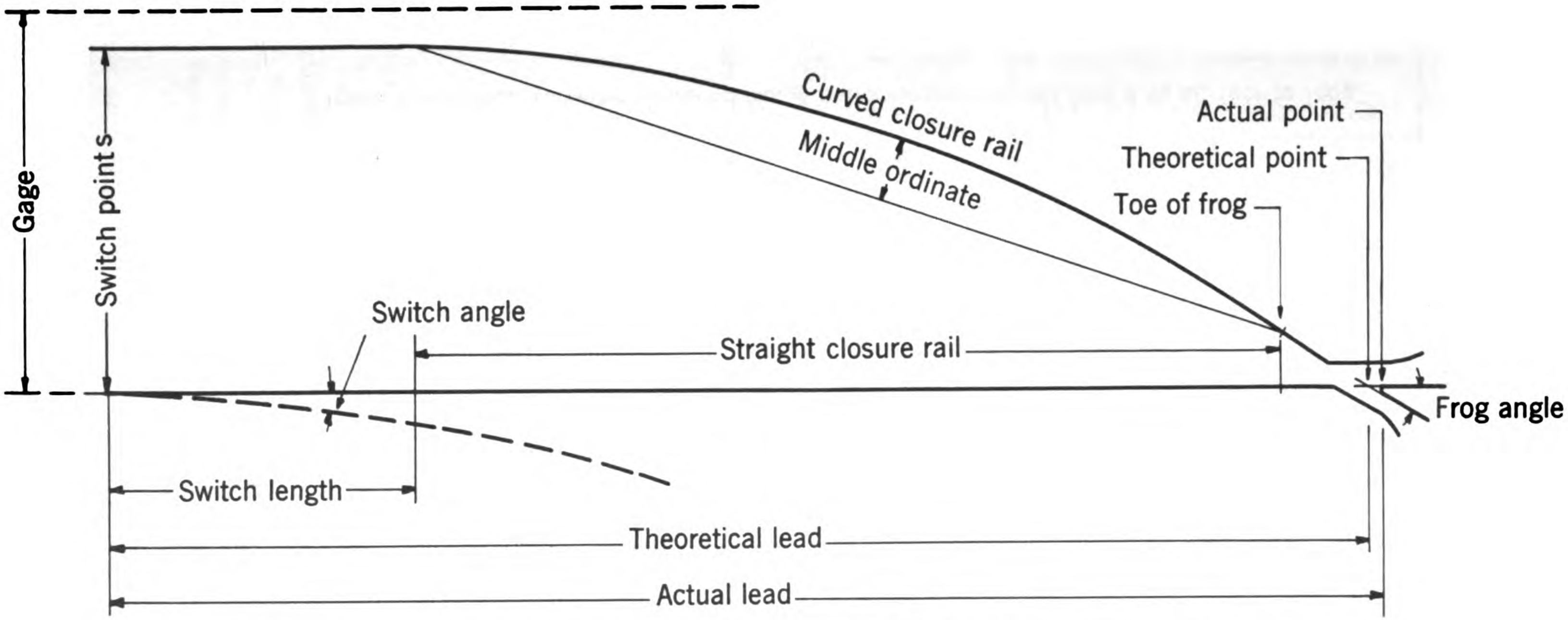
The approximate degree of curvature $= \frac{573}{\text{radius}}$

Example: radius = 50′

573÷50 = 11.46 degrees

= 11°-27′-36″

Figure 7. - Middle-ordinate curve data



Recommended turnout dimensions for various frog sizes and track gages can be obtained from American Mining Congress Handbook "Construction and Maintenance of Haulage Roads."

Figure 8. - Turnout nomenclature.

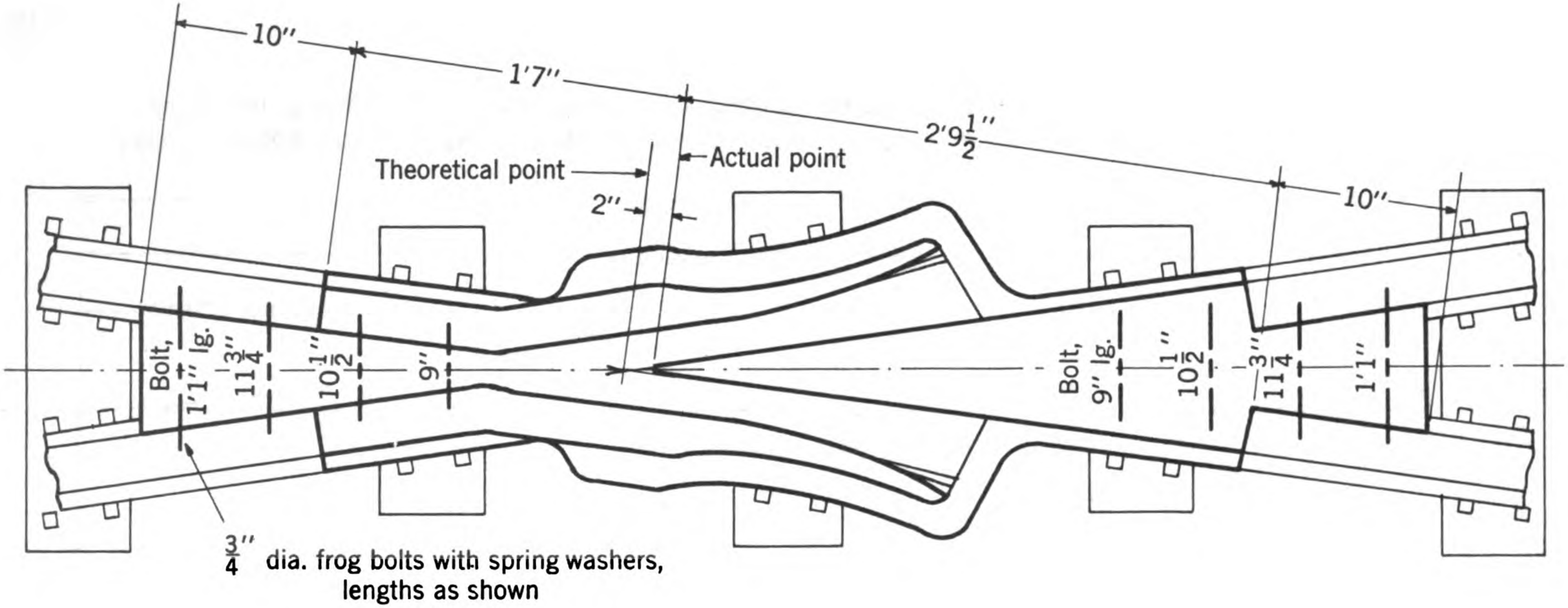


Figure 9. - Sketch showing 60-pound No. 4 solid manganese rail frog 4 to 4½ inches long.

TABLE 3. - Outer rail elevation for 42-inch-gage track[3]

Radius of curve (feet)	Speed - (miles per hour)									
	4	6	8	10	12	14	16	18	20	25
	Superelevation (inches)									
20	2-1/4	5	5	5	5	5	5	5	5	5
30	1-1/2	3-3/8	5	5	5	5	5	5	5	5
40	1-1/8	2-1/2	4-1/2	5	5	5	5	5	5	5
50	7/8	2	3-5/8	5	5	5	5	5	5	5
60	3/4	1-5/8	3	4-5/8	5	5	5	5	5	5
75	5/8	1-3/8	2-3/8	3-3/4	5	5	5	5	5	5
100	1/2	1	1-3/4	2-3/4	4	5	5	5	5	5
125	3/8	3/4	1-3/8	2-1/4	3-1/4	4-3/8	5	5	5	5
150	1/4	5/8	1-1/4	1-7/8	2-3/4	3-5/8	4-3/4	5	5	5
200	1/4	1/2	7/8	1-3/8	2	2-3/4	3-5/8	4-1/2	5	5
300		3/8	5/8	7/8	1-3/8	1-7/8	2-3/8	3-1/8	3-3/4	5
400		1/4	1/2	3/4	1	1-3/8	1-3/4	2-1/4	2-3/4	4-3/8
500		1/4	3/8	1/2	3/4	1	1-3/8	1-4/8	2-1/4	3-1/2

[3] American Mining Congress, Construction and Maintenance of Haulage Roads.

Formula for Rail Elevation.

E = Elevation of outer rail (inches).
G = Gage of track (inches).
V = Speed of trip (miles per hour).
R = Radius of curve (feet).
0.067 = Constant based upon gravity pull:

$$E = \frac{0.067\ G\ V^2}{R}$$

Following are standard angles assigned frog numbers:

Frog No.	Angle
2	28° - 04' - 21"
2-1/2	22° - 37' - 12"
3	18° - 55' - 29"
4	14° - 15' - 00
5	11° - 25' - 16"
6	9° - 31' - 38"

Frog Nos. 2, 2-1/2, and 3 are usually used for room turnouts. Frog Nos. 3, 4, 5, and 6 are commonly used for main-haulage-road turnouts. Frog Nos. 5 and 6 are recommended where traffic is expected to be fast.

Switch lengths should conform to turnout-curve radius and to the expected speed of traffic. For example, a greater curve radius will necessitate a longer switch for smooth traffic. The tapered end of the switch is called the point and the blunt end the heel. Switches of tee rail are commonly termed "split switches." Guardrails are recommended for curves and on turnouts to protect against damage from wrecks and derailments.

All switches should be installed complete with connecting rods and parallel switch throws.

Suggested procedure when installing turnouts is:

1. Carefully study the drawing showing the size turnout to be installed (fig. 8). Ascertain that all material and tools are at hand.

2. Locate the point of frog and the point of switch from engineer's marks.

3. If joints in straight track interfere with switch points or guardrails, make the necessary changes.

4. Cut the straight track rail at the proper point, and bend it with a rail bender to form a curve stock rail. The knuckle should be located as illustrated in the turnout drawing. The curved stock rail should not be sprung into position with partly driven spikes.

5. Widen the gage approximately one-half inch between the heel of the switch and toe of the frog, and complete the turnout track.

6. When placing switch points, assure that the heel spread is the same as shown on the drawing and that the point of the switch strikes the rail first when the switch is thrown, to prevent gaping.

7. If tie plates are used, place the tie plates in proper position, measuring from the frog point, as shown on the drawings.

8. Adjust the frog into proper position, and connect the straight track by placing the straight closure rail and switch point to position.

9. Adjusting the switch stand:

   A. Connect the switch stand, connecting rod, and spring head rod. Adjust the switch stand to give proper throw, as measured over the head rod.

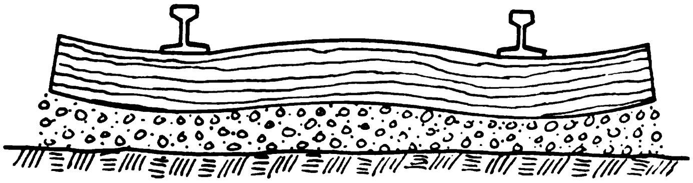
   B. With the arm of the switch stand in vertical position, set the switch points at half-throw locations, each point the same distance from the rail against which it fits.

   C. Assure that the switch stand is parallel to the track and spike stand in position.

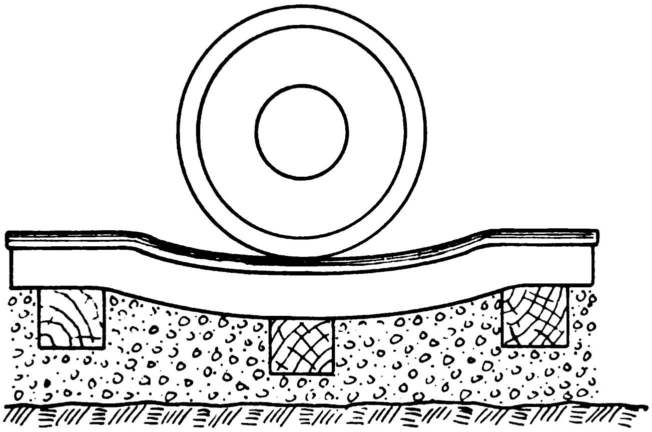
   D. The spring connecting rods should be adjusted to assure that the spring will be under slight compression when the switch is thrown in either direction.

   E. Ballast should be kept below the switch rods, connecting rods, and throws to allow free movement of these pieces.

Tamping Ballast. - Good tamping is of greatest importance. Unless all ties are properly tamped, good surface and alinement cannot be maintained. Poor tamping practices are one of the principal causes of bad track (fig. 10). It is important that the ties should have a firm support; therefore, the ballast must be tamped under the ties particularly under the ends and immediately under the rails (fig. 11). If the ballast is permitted to remain loose, the locomotive and trip cause undulating action, which is detrimental to track alinement and hazardous to traffic operation. If the ballast is tight at the center and relatively loose on the ends, a



A Tie too light
Loose tamping under rails, effect on tie



B Effect on rail

Figure 10. - Results of improper tamping.

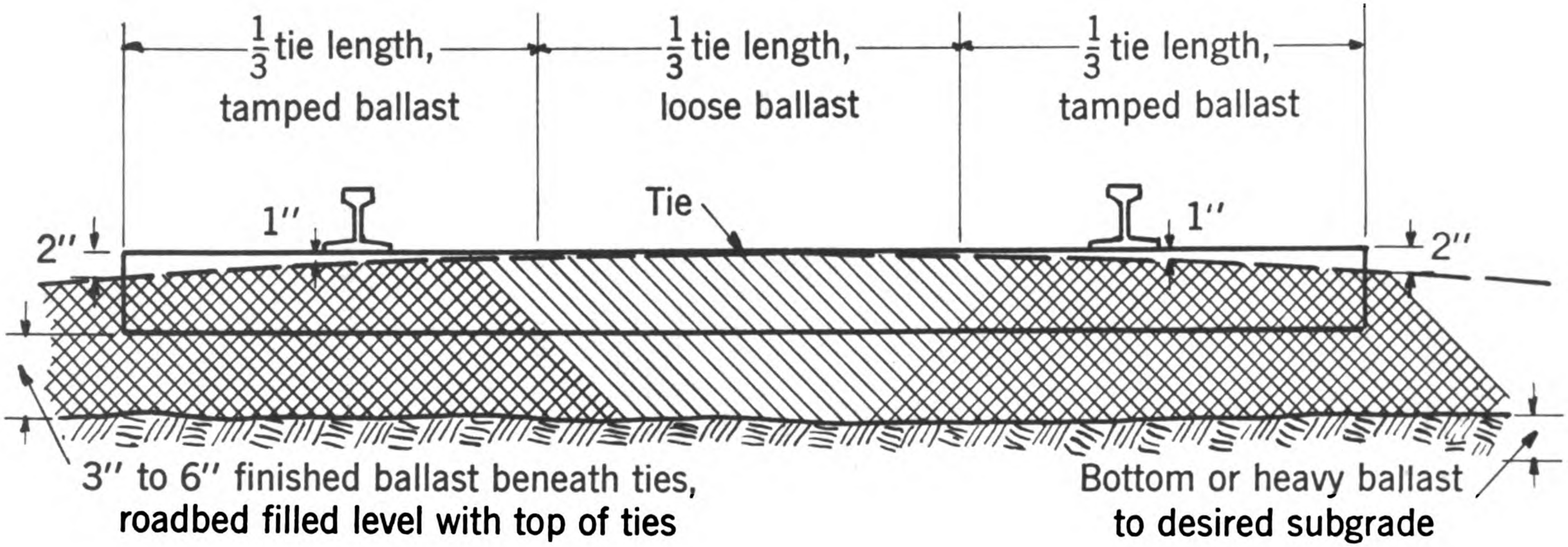

$\frac{1}{3}$ tie length, tamped ballast
$\frac{1}{3}$ tie length, loose ballast
$\frac{1}{3}$ tie length, tamped ballast
Tie
1″
1″
2″
2″
3″ to 6″ finished ballast beneath ties, roadbed filled level with top of ties
Bottom or heavy ballast to desired subgrade

Figure 11. - Sketch of proper tie-tamping procedure.

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common condition referred to as "center pack," misalinement and tie breakage occur, and a rocking motion will develop with moving trips that is conducive to derailments.

The recommended procedure to follow when ballasting haulageway is:

1. Aline the track before filling with ballast.

2. After the track is alined, fill in with ballast.

3. Raise the track to grade and level it.

4. Tighten all ties, and check track joints to assure that they are straight, level, and resting between ties.

5. Start tamping solidly from ends toward the center, leaving approximately 18 inches in the center to be filled and tamped lightly.

6. Maintain ballast below the tops of ties.

7. Check surface and alinement from time to time while tamping.

8. Directly after new track has been in service, a crew should go over it, resurfacing all places that have settled, adding ballast and retamping where needed. Neglect of early maintenance is a prime cause of rapid track deterioration, with subsequent high maintenance costs.

Trolley Wire. - Trolley wire and sometimes power wires are part of the haulage road. The manner in which these are installed and maintained has a definite bearing upon the efficiency of the transportation system. The following are basic recommendations for the installation of trolley wires.

> Trolley and bare power wires should be supported securely on insulated hangers. On straight runs, where the trolley wire is 5 feet or more above the rail, the hangers should be not more than 30 feet apart; where the wire is less than 5 feet above the rail, the hangers should be not more than 20 feet apart. The hangers should be so spaced on curves that the trolley wire at any one hanger may be disconnected completely without endangering the locomotive operator. Trolley wires should be kept taut to prevent excessive sag between the hangers and should not be permitted to touch the roof, rib, crossbars, or doorframes.
>
> Trolley wires should be hung 6 inches outside the rail and kept as near this distance as possible; the height of the wire above the rail should also be as uniform as possible. This method of hanging wire will reduce the tendency of trolley poles of locomotives "to jump off the wire" and the hazards incident thereto.
>
> Trolley and other bare power wires should be installed on the side opposite the clearance side and shelter holes. Obviously, even if the trolley wire is guarded continuously throughout its length, the electric-shock hazard would be increased if the traveling space and shelter holes were on the same side as the trolley wire.

The size of trolley wires should not be less than 2-0 (American wire gage); 4-0 is preferable. In most mines, trolley-wire of No. 6-0 to 9-0 sizes is installed on main haulageways. The American Engineering Standards Committee recommends hard-drawn copper for trolley wires.

INSPECTION AND MAINTENANCE OF HAULAGE ROADS

Without an adequate maintenance program, trouble-free experience with the best installed track will be short lived. Track inspection consists of observation, with notation for the correction of defects known to cause track failures. The following are common causes of track failures, with suggested corrective action.

Common Causes of Track Failures

Roadbed and drainage

Defect	Cause of defect	Corrective action
Low joints	Loose track bolts, loose ballast, worn angle bars, poor drainage, wheel hammer at a bad joint.	Drain, assure adequate drainage, replace defective material, raise joint, reballast, and retamp.
Low rails	Loose ballast, poor drainage, subgrade subsidence.	Drain, assure adequate drainage, raise the track, install additional ballast, and tamp.
Loose ballast	Improper tamping.	Replace ballast, and retamp properly.
Tie pumping	Inadequate drainage.	Remove water, assure adequate drainage, raise track reballast, and tamp.
Grade subsidence	Soft bottom, inadequate drainage, improper roadbed materials.	Use suitable ballast, and drain properly.
Center pack	Improper tamping, ties too short, loose ballast, under rails or tie ends.	Loosen ballast under center of the track, and tamp firmly under rails and tie ends. Use longer ties, if necessary.
Wet roadbed	Poor drainage.	Continuous drainage by ditches to collecting points.

Mine ties

Defect	Cause of defect	Corrective action
Decay	Fungus growth, poor drainage.	Use treated ties if service warrants; replace decayed ties when found unserviceable.
Rail cutting	Soft woods, soft bottom, loose spikes, rail tilting permitting edge to cut into tie during traffic.	Drain bottom where necessary. Correct factors, such as loose spikes or tilted rail. Install tie plates.
Wear	Excessive derailments.	Correct cause if possible.

Rail

Loose spikes	Rotted ties, undersize spikes, poor spiking practice.	If tie is sound, remove and respike tie properly, plugging old spike holes. If tie is not sound, install a new tie.
Improper gage	Misalinement. Loose fastenings and practice of rerailing cars by pulling them through switches.	Correct alinement. Replace worn parts, respike track, install gage rods, and correct injurious practices.
Broken rails	Derailments - Gapping rail ends. Too wide. Tie spacing.	Abut rails together, use new rails, space ties properly use full-size, full-bolted splice bars at track joints.
Loose joints	Insufficient or loose track bolts. Splice bars too short.	Periodic inspection and preventive maintenance. Use lock washers with track bolts. Install full-size standard splice bars.

Turnouts

The following parts should be thoroughly examined at regular intervals, with prompt corrective action.

Part	Things to look for
Switch points	Check heel spread for correct distances, and see that connection to closure rail is secure. Check switch points for excessive wear.

Part	Things to look for
Head rods	Check for correct throw distances, and see that all bolts and clips are tight.
Closure rail	See that closure rail is securely spiked. Particular attention should be given to the switch heel of the curved rail.
Frogs	Examine frog for loose bolts, and see that it is securely fastened to ties. Check the frog for excessive wear or damage.
Switch throw	Check the adjustment of the switch throw, and assure that it exerts equal pressure on the switch points when they close against the rail.
Guard rails	Check guardrail fastenings to see that they are tight and that proper stock-rail clearance exists.
Cleanliness	Keep switches and frogs clean and free from ballast, coal, or other material. Keep haulage roads free from miscellaneous debris. Do not permit ballast to accumulate on top of ties.

APPENDIX

The following information is given as a guide and to assist individuals plannin to construct or repair haulage roads.

Track Crew and Tools

Standard crew working on construction of class A or B track is generally seven men. Each crew should be equipped with the following tools:

1 spike bar
2 spiking mauls (6 lb.)
2 track gages (metal).
2 tie forks
1 level board 5 feet long.
2 solid wrenches (1-1/4 inch jaw - one end pointed for drift).
2 track chisels, 5 lb.
1 50-foot metallic tape (not steel), graduated in feet and inches.
2 iron plumb bobs.
4 tamping tools (use air tampers where available).
2 square-point dirt shovels.
2 round-point dirt shovels.
1 rail bender.
Chalkline.
2 rail tongs for 60-lb. rail.
4 alining bars 4'-6" long, one end pointed.

Material Necessary for Complete Turnout

The following list of material necessary when 60-pound rail is used includes what is needed for installing a turnout. Material for various size turnouts and different weight rails can be obtained from manufacturers' specifications and handbooks.

Frog (fig. 9)

(a) 60-pound No. 4 solid frog 4 ft. - 4-1/2 in. long.

(b) 1 set of bolts for No. 4 solid frog consisting of:

- 2 bolts 3/4 in. x 1 ft. 1 in. long
- 2 bolts 3/4 in. x 11-3/4 in. long
- 2 bolts 3/4 in. x 10-1/2 in. long
- 2 bolts 3/4 in. x 9 in. long

Complete switch - 60-pound, suitable for No. 4 turnout

- 1 switch stand
- 1 connecting rod for switch stand
- 1 pair switch points (10 ft. 0 in. long)
- 1 spring type head rod
- 1 second rod
- 6 slide plates No. 1
- 6 braces for slide plates
- 6 plain plates No. 2
- 2 heel plates No. 3, right and left hand
- 2 heel plates No. 4, right and left hand
- 2 heel-block assemblies

Closure and guard rails - 60-pound weight

- 1 straight closure rail for no. 4 turnout
- 1 curved closure rail for no. 4 turnout
- 2 guard rails with proper clamps

Gage Rods

- 1 gage rod ahead of switch points
- 2 gage rods installed between toe of frog and heel of switch on lead rails.

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